Designing pre-commercial procurement: how procurement practices facilitate commercialization of innovative solutions

Summary:
This research identifies and quantifies factors influencing the commercialization of innovative solutions developed through pre-commercial procurement instruments, specifically the Dutch SBIR program. Through a GLM- and OLS-analysis on the basis of public data and semi-structured interviews, we find that commercial aspects of an innovative solution should be emphasized more in the early stages of the contracted R&D project so suppliers consider possible commercialization issues for their innovations early in development. This study contributes to the literature by examining how R&D procurement processes can influence successful market entry of new products or services.

Keywords: Public procurement, NPD, Supplier involvement, Pre-commercial procurement

Introduction

Research has shown that supplier involvement in new product development (NPD) leads to improved innovation performance (see for instance: Dröge et al., 2004; Carlsson et al., 2011; Luzzini et al., 2015). Especially a higher extent of supplier responsibility can improve the effectiveness (e.g. quality) and efficiency (e.g. speed) of development projects (Suurmond et al., 2020). Besides manufacturing industries, these effects are also found in more service-oriented sectors (Suurmond et al., 2020)

Public buying organizations, too, increasingly involve suppliers more extensively in creating new or improving existing products and services, particularly in public service delivery. Also in the public sector, NPD through supplier involvement is linked to positive innovation outcomes (Aschhoff & Sofka, 2009). The goals in public procurement of innovation can differ from those in a private-sector setting. In a private setting, the buyer generally involves suppliers to create or improve an innovation to be integrated in core business processes. In public procurement, the solutions do not have to fulfil the need of the buying organization directly, as broader societal concerns may also be the focus (Rigby, 2016). Edler and Georghiou (2007) argue that public procurement of innovation could help tackle societal challenges. Innovation-stimulating public procurement instruments and projects can thus be of great importance for society and an evaluation of them is valuable. This is especially true considering the profound impact of public procurement on the economy; it constitutes 12.2% of European GDP in 2017 (European Commission, 2017).

Public procurement to help trigger wider innovation and technology development is generally defined as ‘catalytic’ pre-commercial procurement (PCP), where the eventual buyers and/or users of the innovation solution are often not public organizations (Iossa et al., 2018). In ‘non-catalytic’ PCP projects, the solutions are to be procured by a public sector buying organization following the initial R&D phase (e.g. a new type of sound barrier by the Department of Infrastructure). Another instrument public procurers can use to create non-catalytic innovation is the Innovation Partnership (IP), where supplier and public organization set out to create a long-term partnership to develop an innovation (Iossa et al., 2018). Contrary to PCP, the supplier is contracted for both innovation development (involving R&D) as well as the commercialization / integration phase. In contrast, these phases are strictly separated in PCP projects, each entailing a distinct contracting process (and thus possibly a different supplier).

Although, for both PCP projects and IPs the aim is that the created innovations are readily available to either the public procuring organization or private sector customers after their development, in practice many developed solutions are subsequently not adopted by end-

users. This possibly results from problems in the early R&D phase. The decisions and practices in this stage influence the process and considerations for subsequent R&D and commercialization phases, for example the criteria to which the solutions are tested. In these early stages of NPD, suppliers are often not involved and advanced market / end-user knowledge may be lacking (Conway et al., 2017). Of the two aforementioned instruments, the IP may be better suited to prevent deficient early stage processes from hindering commercial success. As the R&D and commercialization phases are more integrated and are characterized by continuous involvement of the same supplier, the criteria applied in the initial supplier selection and award decisions will typically reflect considerations for successful end-user adoption (e.g. supplier capabilities for ramp-up). PCP, in contrast, stops short of commercial procurement: a separate tendering process is initiated to buy the "production" of the new innovative solution, thus making it harder to align the considerations relevant to development versus commercialization/implementation.

Our study examines what processes are relevant in the (earliest) R&D phases to align these factors better. Empirical research on effective design of these processes to facilitate subsequent commercialization and adoption of innovations under development, is limited. Previous work focuses on commercial procurement processes for market-ready solutions and underplays R&D procurement processes (see for instance: Georghiou et al., 2014; Uyarra et al., 2014). In addition, research emphasizing R&D procurement (e.g. Iossa et al., 2018) does not consider private-sector procurement practices that contribute towards commercialization. Addressing this gap in literature is important, because good process design can improve the effectiveness and efficiency of development projects tackling societal challenges. Furthermore, it can provide insights into how specific processes related to early stage supplier involvement influence later integration and adoption of the innovation at scale. Consequently, this research could have implications for public and private procurers, and policy makers. Both the public and private procurement field can learn from each other's best-practices. Recent work also recommends more interaction between the two fields (Dialogic, 2017).

Theoretical Framework

To engage in NPD in collaboration with suppliers, open innovation instruments can be deployed (Schiele, 2010). These open innovation instruments describe different ways in which buyer and supplier interact to propose, develop, and integrate innovative solutions.

Homfeldt et al. (2017) identify different instruments that can be beneficial for innovation performance under different circumstances in the automotive industry. They distinguish between "push" and "pull" instruments in which the supplier presents its innovative solutions to the buying firm or is challenged to design a solution for a problem identified by the buying firm, respectively. An example of a "pull" innovation instrument is the supplier competition, in which suppliers compete on developing an innovative solution for a specified problem of the buyer. Technology fairs and shows are typical "push" instruments where suppliers bring new market trends and innovations to existing or new buyers.

Besides the automotive industry, open innovation instruments are also widely applied in public procurement. The innovations generated from these instruments in public procurement can aid in addressing societal challenges (Edler & Georghiou, 2007). An overview of these innovation-stimulating instruments is provided in the following section.

Open innovation instruments in public procurement: PCP and IP

Iossa et al. (2018) make a distinction between two types of open innovation instruments applied in public procurement: pre-commercial procurement (PCP) and the Innovation Partnership (IP). PCP is often utilized when public organizations identify a problem for which no solution

yet exists on the market. An example of a PCP instrument is the Dutch Small Business Innovation Research instrument (SBIR) where (mostly) start-ups and SMEs propose their solutions in a tournament format with two rounds. In the first round, multiple suppliers can propose ideas and conduct feasibility research. In the second round a limited number of suppliers are invited to develop and test their solutions. After this second round one (or a few) winner(s) remains. These winners do not receive a guaranteed contract to deliver their innovative solution to the public procurement agency after this initial tournament. A separate commercial procurement procedure, where every potential supplier can bid for, is initiated to determine from which party to procure the (near) market-ready solution. In fact, public organizations may not even procure the PCP-funded solutions and instead be sold in private-sector markets. PCP projects targeting solutions that do not necessarily have to be adopted by the R&D buying agency are also known as catalytic PCP projects (Rigby, 2016). Innovations under development to be subsequently procured and used by the public buying organization, on the contrary, result from projects known as non-catalytic PCP.

The IP is an instrument that can be used to create a long-term buyer-supplier relationship for the development and subsequent commercialization of innovative solutions that directly satisfy the demand of the buying organization (Iossa et al., 2018). Thus, the buyer's goals when using IPs are comparable to those in non-catalytic PCP projects; develop with and subsequently buy from suppliers an innovation that satisfy their needs directly. The difference between the two is that in an IP, the supplier and buyer have more room to negotiate previously defined requirements during the project compared to a tender process in non-catalytic PCP. This is because, in an IP, the supplier who develops the solution is generally also the one selling the innovation and no new tender process is started for the commercialization phase.

Stated differently, in PCP the R&D and commercialization phases are separate, while in IP the two are bundled. This disconnect between development and commercialization in PCP, can lead to undesirable outcomes for both the public agency as well as the supplier; i.e. the innovation does not appear on the market and will therefore not solve the societal challenge the public agency attempts to counter. Hence, choosing an IP may be the wisest course of action for public procurers, as important considerations for the scale-up of the innovation can be addressed more easily in early stages of R&D. This is especially true when the technology sourced as well as the potential suppliers are not immature.

Nevertheless, the PCP method may still be preferred sometimes. Telgen et al. (2012) argue that public procurers have a higher accountability and responsibility to ensure equal opportunity for all (potential) suppliers. PCP offers more opportunities for suppliers to enter and compete for either the R&D procurement or commercial procurement contracts. Moreover, during these stages multiple suppliers compete instead of one, which leads to a more transparent process. Furthermore, an IP may not be suitable for catalytic innovations, since there is not one specific buying organization for which the solution is created. Indeed, Iossa et al. (2018) argue that the R&D and commercial phase should be separated when the specificity of the sought solution is lower (e.g. catalytic projects), since the higher (external) market demand will stimulate the supplier's effort in the R&D phase.

Therefore, the next sections will examine the processes related to PCP projects and how they should be designed in order to negate the gap between development and commercialization. Afterwards hypotheses are formed and tested to identify the factors influencing the probability of successful market entry / organization integration.

The PCP process: R&D phase and commercialization phase

Iossa et al. (2018) describe the PCP's R&D process as all development efforts until the moment of large-scale production. The resources invested in this stage are targeted to finding a concept solution to the identified problem, not a solution to be immediately implemented. In a typical

PCP project, Phase 1, 2, and 3 are concerned with the creation of this concept solution by multiple suppliers (development, prototyping and testing respectively). Most decisions, which concern the kind of solution targeted and how the processes during the R&D procurement phase will be are made before the actual execution of the project however. Often the buying organization solely makes the decisions in this preparation phase. Looking at an example, the Dutch SBIR program, a form of PCP targeted at start-ups and SMEs, the decisions in the preparation phase (i.e. Phase 0) include the organization of the decision-making unit (as described by Webster & Wind, 1972) and the creation of a request for proposal (PIANOo, 2020). This latter process includes decisions such as: which goals are pursued, what the specifications of the project are, and what the selection criteria for the innovative solutions are. Furthermore, the decision on the composition of a review panel, who test the quality of the innovations, is made. Different from the buying organization, the Dutch enterprise support agency (RVO) executes the project. They are the first contact for suppliers and are responsible for facilitating all processes related to the program (e.g. distributing documents).

After the R&D process, the concept solution still has to be scaled-up or integrated in an organization to actually help solve the initial problem. This is where the commercial procurement process starts, also known as Phase 4. If the public organization decides to procure a developed solution, it is allowed to make use of a competitive procedure with negotiation or a competitive dialog (European Commission, 2014; Iossa et al., 2018). Like the R&D procurement process, these procedures include a preparation phase where selection criteria and specifications are formed (UK Government Commercial Function, 2020). This is followed-up by multiple rounds of tendering and negotiation / discussion regarding specifications and KPIs. One can already infer that there is possible overlap between the commercial and R&D procurement stages, as the outcome and the considerations in Phase 0 of the R&D process could be aligned with the decisions in the preparation phase of commercial procurement.

However, in the commercialization phase other factors are more prevalent as compared to the R&D procurement. In a private-sector setting, Le Dain et al. (2011) and Sjoerdsma & van Weele (2015) identify factors such as the ability to cut costs, operational performance (e.g. product quality), and relational alignment as indicators for supplier performance for NPD in the *integration* phase. Those studies furthermore show that the most important performance indicators for suppliers in the *R&D* phase are related to idea generation, though relevant cost measures and compliance to early budget are important too. However, not only the economic feasibility of the product should be assessed, also the operational / organizational feasibility for scale-up.

To align the two processes, the effective execution of procurement processes may help. The next section will elaborate on what these procurement related practices are.

Procurement's role

As mentioned earlier, innovation procurement instruments in public sector settings have an inherent misalignment between development and commercial ramp-up. Differences in important assessment criteria between the R&D and integration phase are also observed in private-sector procurement settings (Le Dain et al., 2011; Sjoerdsma & Van Weele, 2015). What role can the procurement function play to bridge the apparent gap between these two phases? Nijssen et al. (2002) show that there is a positive relationship between an extended role of the procurement function and innovation outcomes. Schiele (2010) provides an explanation for this observation: purchasers can simultaneously identify and help develop supplier innovations and make the product more company- and market-ready. This "dual-role" is best possible when a company involves a more traditional procurement team focused on costs (i.e. "life-cycle sourcing") as well as a more engineering-focused procurement team emphasizing technological aspects (i.e. "advanced sourcing"). A balanced role between the

two teams is desirable, though the life-cycle team is perhaps better placed to provide suggestions for successful integration. For example, they could set a target cost early in the R&D phase so the supplier can anticipate this during development (Ellram, 2000). Homfeldt et al. (2017) also stress procurement's early assessment of the economic viability in the R&D stage as an essential activity. Influencing costs in the early stage is important as design decisions at this stage can determine 70 percent of total product costs (Ellram et al., 2020). Hence, the processes described display the ability of procurement to nudge suppliers in considering the right criteria for adoption by the buying organization and /or the wider market.

Although literature on private-sector procurement highlights a positive role for procurement in enabling scale-up of innovations, there is scant empirical research on how procurement processes and practices (e.g. assessment of commercial viability early on) can contribute towards increased commercialization and adoption of innovative solutions in public procurement settings. Georghiou et al. (2014) do provide some insights into how public procurement processes should be organized to facilitate innovation, but their study focuses on commercial procurement settings. Indeed, the authors acknowledge the lack of simultaneous attention to the R&D procurement and the commercial procurement stages by public procurers.

This research seeks to address the limitations in prior literature by investigating how R&D procurement processes should be designed to facilitate subsequent commercialization of developed innovations. Focusing on the structure and implementation of the Dutch SBIR, as a prominent PCP example, the research sets out to answer the following research question:

What procurement practices in the R&D **phase of pre-commercial procurement influence the subsequent innovation success in the commercialization phase?**

Hypotheses

Through the development of hypotheses, this section will elaborate further on the proposed research question. To do so however, the dependent (outcome) variable, innovation success in the commercialization phase, should be explained.

Adoption of the innovative solution, either directly by the government or by the market, is important for fulfilling the purpose of PCP; tackling societal problems through the development of innovative solutions. Therefore, successful market entry is the most important criteria of success. Besides direct measures of success, also indirect success should be measured. This is done by not only considering winners of a PCP project, but all participating supplier that may have benefited from PCP e.g. through increased cooperation with other buying firms, capability development, and improved understanding of possible routes to market for their innovations (Selviaridis, forthcoming). Earlier research also suggests that supplier firms increase their R&D investment after participating in a PCP project (Dialogic, 2017). Therefore, the objects of study are the PCP projects and not the solutions themselves. This is because, the cumulative success in the market per project should be assessed (e.g. proportion of succesful market entries). Furthermore, in line with Suurmond et al. (2020), not only the effectiveness of the process should be measured (i.e. market entry), but also the efficiency. This is related to the speed of market entry, and time-to-market is the measure used. In the data and methodology section, an elaboration on the measurements of market entry is provided.

From the description of the PCP structure can be inferred that many decisions that can influence the project are made in Phase 0; before the actual execution of the project. Indeed, Conway et al. (2017) stress the importance of this preparation phase and related processes which are too often underplayed. In this phase, the design of the project is decided upon including factors such as: the financial compensation structure and the specifications deemed

necessary for the innovative solutions. Furthermore, in this stage the criteria and their weights on which the suppliers are reviewed are established.

One such criterion is the economic viability of the innovation. Indeed, Homfeldt et al. (2017) and Ellram et al. (2020) highlight the importance of an early assessment of costs in development to increase the solution's market readiness. Further, Link and Scott (2018) show that particularly innovations with high commercialization risk benefit from the SBIR program, warranting extra consideration of this criterion. Besides the costs, the capabilities and resources of the supplier to produce the innovation effectively on a large scale should also be assessed. In a typical assessment of proposals in the Dutch SBIR, one criterion parallels the commercial feasibility, both in terms of costs as well as organizational competence: economic perspective (RVO, 2019). The economic perspective resonates the most with the above described commercial barriers, as it is concerned with factors such as market position and management capacity. This leads to the following hypothesis:

H1a: Choosing a higher weighting of economic perspective in the preparation phase leads to more successful market entry.

Another factor determining the design of a PCP project is the amount of entrepreneurial risk the buying organization is willing to assume. Link & Scott (2010) describe this entrepreneurial risk as the public agency accepting the uncertainty of success of an innovation in a SBIR project. Part of the risk associated with R&D activity is shifted to the public agency. As the agency assumes most of the risk, competing R&D suppliers can more easily realize a favorable rate of return for commercialization.

Within the project, there are three possible indicators of the entrepreneurial risk a buying organization is willing to take. First, the total level of financial compensation available per project (Bearse & Link, 2010; Lanahan, 2010). When a higher portion of R&D costs are compensated by the buying agency, the required return on investment for the private-sector supplier firm is lower, possibly resulting in easier market entry. Further, the weighting of the price criterion is a possible barrier related to entrepreneurial risk (Georghiou et al., 2014). A higher relative weighting for price can be viewed as an act of shifting more risk from the public buyer to suppliers, which then require a higher rate of return for their innovations. Indeed, Homfeldt et al. (2017) note that procurers are often incentivized to focus on savings rather than innovation. This hypothesis is different from what is proposed in H1a, since economic viability refers to the feasibility to enter the market while pricing is concerned with achieving savings for the buying organization specifically. This problem with price emphasis is most notable in non-catalytic projects. Lastly, public buying agencies could add more specific requirements to the review criteria to ensure specific policy goals are met. This can limit suppliers in their innovative possibilities which could impact market entry in the commercialization phase (Georghiou et al., 2014). Adding extensive, detailed specifications to the supplier's task implies a limited level of supplier responsibility (Azadegan & Dooley, 2010). A supplier taking on more extensive development responsibilities in a NPD project is found to lead to both higher quality of the innovative solutions, and to higher development efficiency (Suurmond et al., 2020). Therefore, a negative relationship between the level of extensiveness of specifications and successful market entry can be expected. Given the three indicators of entrepreneurial risk shifting from public organization to supplier and their proposed effect on market entry, the following hypotheses are proposed:

H1b: Choosing a higher overall compensation scheme in the preparation phase leads to more successful market entry.

H1c: Choosing a higher weighting of the price criterion in the preparation phase leads to less successful market entry

H1d: Setting a higher number of additional specifications in the preparation phase leads to less successful market entry.

Besides the project/problem design, the structure of the decision making unit is also defined in Phase 0. In other words: which actors are involved and what are their roles in the project? The capabilities and roles of these different actors could influence the outcome of a project. Suppliers participating in the SBIR program reported on two barriers referring to the design of the decision unit: lack of interaction with the procuring body and limited capabilities of the procurers (Georghiou et al., 2014).

Capabilities of the buyers can be related to the overall purchasing maturity of an organization. Such maturity models are for instance proposed by Van Weele et al. (1998), who describe an organization's development in terms of purchasing maturity and the increasingly strategic role that procurement is tasked with. Highly competent procurers are often present in a mature purchasing organization. These procurers are more capable of successfully engaging in supplier collaboration and can thus indirectly influence the outcomes of a NPD project positively (Luzzini et al., 2015). Iossa et al. (2018) also call for a more strategic view of public procuring organizations to deal with the risk management aspects of the projects. Such a strategic view is typically associated with a higher maturity level. Therefore a positive relationship between a higher maturity and market entry success can be expected

Also, direct and extensive contact with the public organization may positively influence market entry compared to heavy reliance on an intermediate agency for communication and development support. In the Dutch SBIR, the latter is observed as suppliers often not interacting directly with the buying agency, but only with the more process-oriented executing agency, the RVO. The intensity of collaboration between RVO and buying agency, and thus suppliers, varies per project. The RVO executes the tender procedure and manages all supplier interactions related to the awarded R&D contracts. The buying agency, however, possesses problem-specific expertise that is relevant for bidders. Indeed, Weeks and Feeney (2008) argue that there should not be a big knowledge/capability gap between buying organization and innovator to achieve more sophisticated solutions. Therefore, a closer form of collaboration between suppliers and buyers (i.e. less influence of the executing agency) is expected to have a positive effect on market entry success.

Based on the proposed effects of these two influencing factors, we propose the following hypotheses:

H2a: A PCP project originating from a contracting agency with a more mature procurement function, is more likely to result in successful market entry.

H2b: A PCP project where the contracting agency is represented by an intermediate party, is less likely to result in successful market entry.

Finally, related to both the design of the project as well as the organizational form, is the composition of the review committee who are chosen by procurement officials in Phase 0. The members of this committee and the roles they have could influence the assessment of the proposed supplier project. It is likely that economic aspects receive a better judgment and more attention when more persons with sophisticated market information are in the panel. When the procurement function is not mature, committee members could compensate for the limited competence of procurers. They can take over the role of "life-cycle sourcing", as described by

Schiele (2010), from procurement professionals when these considerations are missing in the initial project preparation phase (i.e. Phase 0). Roles that members with extensive market knowledge can have include business professional, industry specialist or entrepreneur. Based on the above reasoning, the following hypothesis will be assessed:

H3: A PCP project for which a larger portion of the review committee consists of members occupying positions close to the market, is more likely to result in successful market entry.

Data and Methodology

In this research a specific PCP program is examined: the earlier described Dutch SBIR program. By combining TenderNed data on public procurement tenders from 2011 till 2019 and the RVO website, 38 SBIR projects could be identified as finished with Phase 2 (RVO, 2020). TenderNed is the Dutch government's online tendering system. All Dutch authorities are obliged to publish their national and European tenders on Tenderned's announcement platform.

The dataset only includes projects that are complete and for which winners could be identified. Not only the winning supplier of the project are considered, but all firms that participated in Phase 2. This allows for a set of firms that experienced the project in full, hence the impact of the project structure should be more visible. Furthermore, it can be expected that innovations are only commercialized after the SBIR project is completed. Other studies also used this form of data selection (see for instance: Audretsch et al., 2019; Link & Scott, 2010). This filter leads to a reduced dataset of 26 unique projects with full disclosure on 125 firms which finished Phase 2. For the qualitative analysis, three projects that are still working on Phase 2 are also included. Firms participating in these projects can still provide useful insights on the processes and enabling factors in a SBIR project.

The dependent variable, successful market entry, will be measured in two ways reflecting respectively the effectiveness and efficiency of the innovation process: a binary variable reflecting market introduction (yes/no), and an integer measuring (expected) time-to-market (in years). As the current study is mainly interested with the difference between various tender procedures, SBIR projects – and not individual suppliers - will be the unit of analysis. The outcome variable, succesful market entry, will be collected at firm level but aggregated to success per SBIR project. To illustrate, when two out of four firms that participated in a project successfully launched their innovations, the average market entry success of the project is equal to 50 percent. The data for both variables is collected from public sources, such as company websites and the product summaries submitted for the SBIR projects. To complement and corroborate the data, an e-mail survey was distributed to suppliers that participated.

For Hypotheses 1a and 1c, the measurements of economic perspective weighting and price weighting respectively are observed in the project calls (in TenderNed). These project calls are distributed to suppliers and convey information about the project specifications. For Hypothesis 1b, an RVO representative directly provided the financial compensation schemes. To test Hypothesis 1d the project calls were also examined. The goal, as formulated by the buyer, conveys the minimum demands. Any other specification not directly related to this goal can then be classified as an additional specification.

For hypothesis 2a the controlled spend per employee of the procuring agency will be used as measurement. A higher spend per employee would signal a higher maturity level. The spend of different public agencies is retrieved from annual reports and budgets. This is a crude proxy, and ideally MSU+ scores that assess the agencies on maturity and purchasing excellence would have been used. Sadly, these proved unobtainable. This variables measurement will be further discussed in the limitations.

The measurements for hypothesis 2b will, similar to hypothesis 1d, be extracted from the project calls' text. Evidence that an intermediate actor is strongly involved, would be a statement acknowledging that another party executes the project on behalf of the governmental agency. Counterevidence would be statements confirming a closer collaboration between firms and buyer.

Finally, hypothesis 3 will be assessed either based on information from the problem call, documents from follow-up sessions, or data provided by the RVO directly. When the role of a panel member indicates a function close to the market the person will be identified as having sophisticated market information. These functions include: consultants, entrepreneurs, employees in commercial and/or management positions in the industry, and industry representatives. The relative weight of commercial influence in the panel will be assessed by dividing the number of market experts by the total number of individuals in the committee.

Three more (control) variables are included to complete the dataset: The number of (Phase 2) suppliers, whether a project can be labelled as catalytic or non-catalytic, and an industry dummy for which sector the SBIR relates to.

The number of competing firms could influence the processes in place, as more suppliers would mean a more standardized process and less financial compensation per party. Further, it can also positively influence market entry in Phase 4 as more competition can lead to more knowledge spillover effects during the SBIR project. There is also a difference in project set-up between both catalytic and non-catalytic projects, as it can be expected that non-catalytic projects are more focused on the specific end-product for the government. This influences variables such as the entrepreneurial risk assumed by the government, the relationship between suppliers and buyer and the weighting of price. Moreover, the type of project can influence the success of market entry, as the governmental institutions is more likely to act as a launching customer. Lastly, for every industry for which a SBIR is organized, the project set-ups and the probability of successful commercialization is different. For example, the financial compensations to be earned is dependent on the cost-structure that exist in the industry. Likewise, different industries target different markets with various preferences and demands.

Method:

The survey data collected on suppliers of 26 unique projects using TenderNed, RVO experts and questionnaires, is assessed through a GLM fractional regression (as described by Papke & Wooldridge, 1996 and Baum, 2008) and an OLS- regression respectively. The dependent variables in both analyses is the probability of successful market entry and time-to-market.

Furthermore, a follow up, qualitative analysis drawing on 20 semi-structured interviews with supplier representatives that indicated willingness to share further insights was performed for 18 projects. These projects had an average market entry ratio of 45 percent per project. The interviewees all mentioned to be involved in the SBIR trajectory and the development of the product/service. Interviews with these representatives were performed via phone call.

The qualitative analysis has three purposes: validation of the quantitative analysis, observing other factors in the SBIR-trajectory influencing commercialization, and finding possible directions for future research. For the first purpose, questions related to the hypotheses are asked. First however, an open-ended, general question about the experiences with the project is asked. This question served the other two purposes of this qualitative analysis. The semi-structured interview structure allowed for follow-up questions on topics outside the hypotheses.

Given the goals of the qualitative analysis, a cross-case analysis will be performed comparing the responses of the interviews over all SBIR projects for which at least one firm representative is interviewed. This allows for analyzing similarities and contrasts to identify

the factors contributing to successful market entry. The comments of the interviewees are grouped per topic for every project. When a significant proportion of firm representatives mentioned the same topic, then this is evidence for this topic to be a significant factor influencing market entry.

Results

Results quantitative analysis

For the first measure of success, the probability of market entry, a significant negative effect of a higher economic perspective weighting is observed. This is opposite to what was proposed in the hypothesis. For time-to-market a positive effect is observed (i.e. market introduction is slowed down), however it is not a significant effect. Hence, hypothesis 1a is rejected on the basis of the GLM analysis. A possible reason for the observed opposite effect, is that the aforementioned criteria may favor larger and more mature firms over smaller start- and scale-ups. The many small firms that are attracted by this program could be more likely to not proceed to later phases of the program when the weighting is higher, missing out on financial and organizational support. This in turn can explain a lower probability of market entry thereafter.

For hypothesis 1b, the results imply that for every 100,000-euro extra compensation per project, an increase of 0.4 percent point in the chance of successful market launch per project is expected. The limited effect may be explained by diminishing returns as the budget increases. In the short time-frame of an SBIR program (i.e. typically 2 years) the innovative efforts are constrained independent of budget size. For example, organizational changes at the supplier to innovate more effectively may not be possible even though sufficient budget is present.

For the other two measures of entrepreneurial risk assumed by the government, price weighting and number of additional specifications, the effect was found to be insignificant for both analyses. Hence, hypothesis 1c and 1d can be rejected on the basis of the quantitative analysis. The reason that the effect of the price weighting is not significant, could relate to the opposite sign observed for the economic weighting. Perhaps for some project calls the price was not separately weighted but together with the economic perspective of the innovation. The rejection of hypothesis 1d could originates from the suppliers not perceiving the identified specifications as binding.

Also, for the measurement of hypothesis 2a, buyer spend per employee, an insignificant effect is found. A possible reason for the rejection could relate to the measurement method of the hypothesis, as only a proxy for maturity was used. Alternatively, the influence of the contracting agencies (and their specialists) may be fairly limited in Phase 0 and/or during the execution phases.

Furthermore, the probability of market entry is expected to drop by 28.2 percent points when there is an intermediary involved, compared to direct involvement. This effect is significant, hence hypothesis 2b cannot be rejected. This result can be related to the results of hypothesis 2a, as the lack of involvement, the procurers' capabilities, and a knowledge gap between buyer and suppliers are strongly associated with one another. So, the effect of a lower purchasing maturity level could be partly captured by the intermediary coefficient.

Lastly, from the quantitative results can be observed that hypothesis 3 cannot be rejected; An increase of 10 percent in the proportion of market experts (0.1 in absolute terms), is expected to increase the odds for successful market entry by 2.1 percent point. The effect on time-to-market is, comparable to other variables, not significant.

Results qualitative analysis

From the interviews it can be inferred that, the vast majority of firms acknowledges the financial importance of the program. Most firms solely relied on the external budget provided by SBIR, often acknowledging that the project would not have started without. Therefore, a higher budget can increase the innovative efforts of the firms which in turn leads to a higher chance of market entry. This is in line with the quantitative results for hypothesis 1b.

Furthermore, while not many firms acknowledge that they were restricted in their innovative endeavors, there was a pattern of firms criticizing the amount of work for the deliverables. This work was seen as a large burden, not clear and less suitable for start-ups. However, interviewees also acknowledged that the deliverables helped them understand the market better or that they could be used as marketing tool.

Despite the large amount of work, most firms did not feel restricted by the specifications set-out in the project calls. The results of the quantitative analysis confirm this feeling, with an observed non-significant effect of the number of additional specifications. This also corresponds with the earlier raised possibility, that the additional specifications are not perceived as such by the participating firms. Also, the strictness of the review committee concerning the specifications could be less than expected.

Nevertheless, the review criteria were broadly perceived as too little focused on commercialization aspects. Relative to the results from the GLM-analysis (H1a), this view from firm representatives is conflicting. This is perhaps due to the economic perspective criteria focusing more on organizational factors rather than factors enhancing market potential (e.g. identifying customer segments). If this is true, then it would perhaps impact smaller firms more, because of their lower organizational maturity.

The qualitative results for hypothesis 2a and 2b are also not directly confirmed in the interviews. Most firms do not make statements that signal problems with the contracting agency as intermediary or the lack of capabilities of the purchasing organization. A possible explanation for the conflicting results from the quantitative and qualitative analyses is that maturity influences the project design, but not the project trajectory as much. Hence, the competing firms do not perceive much problems as the executing agency (RVO) and the firms execute the project following the framework set in Phase 0 by the buyer.

The interviewees did not frequently question the expertise of the review committee, providing no corroboration for hypothesis 3. The same reason for the difference in results as provided for hypotheses 2a and 2b may apply here: the panel members' impact is confined to the framework designed in Phase 0. They review the innovation on the basis of the criteria set-out in the project calls.

Outside the hypotheses, problems with legislation was the most mentioned issue with the SBIR trajectory. When some firms tried to launch their product on the market, legislation (or a lack thereof) hindered end-users to buy the product. Also often mentioned and strongly related to legislative issues, is the lack of relevancy of the SBIR problem and end-users' demand falling short. To counter these three problems, suppliers advised to increase the involvement of end-users during the SBIR project. The implication is that early involvement would have helped in emphasizing the potential problems in the market, already in the R&D phase. Also, more possibilities for follow-up communication with the government would help post-SBIR to solve some of the problems with legislation and end- user demand.

The above-mentioned remarks are in line with earlier findings, that important consideration have to be made in Phase 0 that influence the remainder of the project. For instance, a higher maturity or firmer involvement of buying organizations can address legislative issues beforehand or prevent a non-relevant project from the start. When this specific knowledge or competence is missing in these organizations, the involvement of end-users could help. This last role could also be assumed by the members of the review committee.

Actively involving them in Phase 0 potentially results in better alignment with the market, specifically when a sufficient proportion of members have sophisticated industry knowledge.

These results were also discussed with representatives of a buying organization involved in three (ongoing) SBIR projects. The buyer acknowledges the importance of involving the panel members or more market expertise in Phase 0. This is important, because specific knowledge within the organization is often not sufficient leading to little attention given to relevancy of the problem in the market. However, it is difficult to involve the committee members in the criteria selection process, because in practice these criteria are chosen in parallel with the panel selection. Separating these processes would slow the SBIR process down and can discourage agencies to choose this program. Nevertheless, the buying organization stresses that involvement of parties or individuals with sophisticated market knowledge would be beneficial. Sufficient representation of this knowledge on the review panel is also seen as an important consideration. In line with remarks made by firm representatives, the buyer also points out that communication possibilities after the SBIR-trajectory are insufficiently present.

Conclusion, Implications, and Future research

This research examines the procurement processes and practices in pre-commercial public procurement (PCP) projects, and more specifically the Dutch SBIR program. Through the development and empirical testing of hypotheses, this study identified several factors pertaining to the R&D procurement and innovation development process that influence the probability of market entry in the subsequent commercialization phase.

From the quantitative analysis evidence is found for a higher budget and a higher proportion of the review panel's members having a function close to the market having positive effects on market entry. Furthermore, indirect involvement of the buying organization is suggested to have a negative effect on market entry as compared to direct involvement. The quantitative analysis does not find support for risk shifting from the buyer to the supplier in the form of too strict budgets or specifications.

This research also suggests from a qualitative analysis based on interviews that too little attention to important market aspects (e.g. demand segments and competition) compared to organizational factors (e.g. resources and management capabilities) is related to less market entry, especially for SMEs. Lastly, it is suggested that a lack of consideration of commercial and legislative factors, and end-user relevance in setting criteria lowers the probability of successful market entry.

Overall, there are some concerns with the difficulties to make the step from development towards the market and the extent to which the SBIR program addresses these issues. Combining the fact that there is a perceived absence of attention given to economic aspects and that the competing firms adhere to the specifications set by the buyer, the importance of the design of the project in Phase 0 is apparent. The review criteria designed by the buying agency can push firms towards considering the factors influencing commercialization in the R&D phase (e.g. legislative issues). The results seem to imply that these considerations are not made at the moment. In fact, this research found evidence pointing towards a direct involvement of the buying party and more members with extensive industry knowledge in the review committee compensating for this lack of attention to commercial criteria at the moment.

The results, however, show no evidence for a lower purchasing maturity being the root cause for not considering certain review criteria. Indeed, the interviewed buying organization mentioned that a dedicated innovation focused procurement team is involved in creating SBIR projects. Yet, the buyer also acknowledges that for certain SBIR projects the topic specific expertise was missing. This could be the reason why commercial criteria are perceived as not

considered enough, while the purchasing maturity does not seem to influence the probability of successful market entry. Properly addressing this inadequacy in expertise beforehand could also address legislative and relevancy issues arising in the commercialization phase. Firms can then consider these problems when developing their product or service during the SBIR trajectory, increasing the odds of successfully entering the market.

Theoretical implications

Some of the conclusions derived correspond to earlier research on factors that enhance market entry success. For instance, in Dialogic's (2017) report on the Dutch SBIR, a majority of interviewees state that testing commercial possibilities is an important reason to enter the competition. Georghiou et al. (2014) also found that most firms would appreciate that the specifications (i.e. criteria) of a project are related to the eventual outcome. These researchers also found that there is often a lack of general market demand for the solutions developed. Conway et al. (2017) stress the importance of the set-up phase in solving demand problems in the market phase early. They also stressed the importance of commercial experience in the review commission, to offer attention to potential problems that can arise in the market. This observation corresponds to other suggestions that procurement should consider the economic viability / costs of an innovation in the early R&D stages (Schiele, 2010; Homfeldt, 2017; Ellram, 2020). Also, a report of CPB (2017), acknowledges that it is important to have enough knowledge and expertise at the demand side, i.e. the buying firm. Having more expertise enter in the early stages of the project development may also solve legislative issues and change government policy (Conway et al., 2017; Dialogic, 2017).

Implications for private innovation instruments can also be found from this study. More specifically, the results imply that there should be enough expertise at the private buying firm about the innovative solutions to be developed with suppliers via innovation instruments (e.g. supplier workshop). Indeed, Weeks and Feeney (2008) argue that there should not be a large knowledge gap between supplier and buyer when the buyer desires to foster innovation at the supplier. Involving specific market expertise is probably easier to achieve for a private firm than for a public buying organization, as sufficient knowledge about market demand should be present at the firm. Nevertheless, this knowledge should be introduced actively in the R&D phase. That is, personnel with knowledge about market demand should be in the teams working on the development of the new product (e.g. the sales or marketing department). Petersen et al. (2005) also state that in the highest level of responsibility for the supplier in new product development (i.e. the "Black Box"), suppliers should be fully aware of customer demands to innovate effectively. A competent and mature procurement function can help in bridging this knowledge gap on demand, and thus achieve better innovation outcomes (Luzzini et al., 2015).

The study extends previous research through examining how the processes in R&D procurement affect the subsequent commercialization. Previous literature focusing on this stage in supplier involvement in NPD is scarce (e.g. Iossa et al.). Compared to this previous work, this study also considers the effect of procurement processes identified in private purchasing literature. As this research shows, identifying and addressing purchasing processes in early stage development is important to improve the effectiveness and efficiency of market entry for innovations.

Policy implications

If the government desires to increase the effectivity of the SBIR program, a few changes can be made on the basis of this paper's conclusions. First of all, involving more market expertise in the early stages of the process is important. More specifically, these experts could be internal to the buying organization when this knowledge is present, or external end-users, entrepreneurs or managers from the industry when the internal expertise is inadequate. Involving the

members of the review committee with this commercial background in Phase 0 could also be an option but with a few caveats. Foremost, is the fact that the creation of the review panel and the criteria often occur simultaneously. Separating these two processes would, according to the interviewed buyer, severely slow-down the process and in turn discourage government officials from choosing the SBIR program. Furthermore, the independence of the review committee may be compromised when involving them extensively in the set-up phase. Conflict of interests with the (potential) suppliers should be considered for every external expert brought in the preparation phase and the review committee. This research also does not advocate for only commercial expertise in creating the project or when reviewing the proposed ideas. Well-balanced consideration of multiple aspects is important, not only the commercial feasibility (e.g. technical, legislative etc.).

Another recommended change is providing more contact possibilities with suppliers after the SBIR project. This could help solve the same issues as the involvement of expertise in Phase 0. There is also some prudence warranted for extensive contact between buying organization and participating firms during the trajectory, to ensure equal treatment for all. Nevertheless, the executing party can more actively promote / facilitate the suppliers to involve other market parties or knowledge institutions in their development process.

Limitations and future research

There are some imperfections in the data collection process of this study. The most apparent example is the small number of projects examined, due to incomplete information on certain variables and firms. While relative to the total population of 38 a majority of the projects is examined, the small population seize would perhaps warrant an even higher proportion to be included in the sample. Furthermore, there was a lack of information available on the maturity of public buying organizations which lead to the use of a crude proxy in the form of total spent.

This information deficiency can also be applied to the firms that were included in the dataset. Not all companies reacted to the survey and/or no other way could be used to find information on market introduction or time-to-market. Especially the time-to-market analysis could have suffered from this, leading to insignificant results.

Furthermore, possible sample nonresponse bias (as described by Blair & Zinkhan, 2006) has occurred. The firms that were unsuccessful in developing a product or service are more likely to be excluded from the dataset, because they would be less willing to talk about failed innovations.

As this research only examines the SBIR instrument in the Netherlands, external validity is also constrained. Caution is warranted when drawing conclusions for similar pre-commercial procurement instruments in other settings or countries. However, the design of this research can be applied to instruments in other countries.

Further research should focus on these different settings, so a better overview of best-practices can be constructed. Indeed, certain countries may have already addressed the recommendations made in this study. Future research in the Netherlands should focus on attaining a higher response rate, to subsequently increase the project sample seize. Different measures for the variables described in this research could also increase the internal validity of new studies.

The conclusions resulting from this research should also be further examined. More specifically, the importance of expertise involvement in Phase 0 and the differences in experience for small and big firms. One possible research strategy would be to follow the process of a SBIR project and examine the expertise available in the preparation phase of the project.

This research has attempted to enrich the literature on factors influencing the effectiveness and efficiency of the SBIR program. Hopefully this research forms a starting

point for further research on the quantification and identification of factors facilitating market entry in PCP. Research in this field can then indirectly contribute to effectively tackling today's societal challenges.

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